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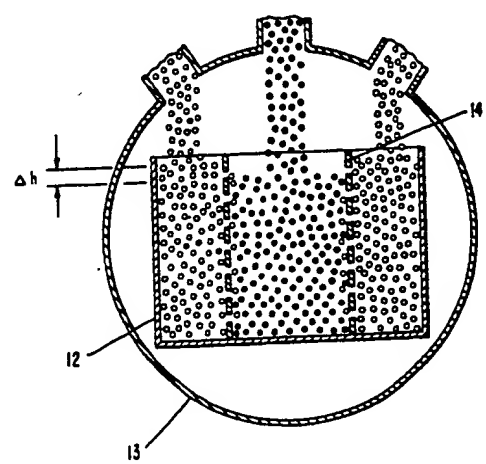
(54) **Method of producing a monolithic alloy component preform.**

(57) Two different powdered alloys are poured into separate regions of a can (12) in a hot isostatic pressing enclosure (13), a screen-like basket (14) separating the two regions and the maintenance of a difference in level (h) during filling allows powder particles of one alloy to pass into the basket (14) and mix with the powder particles of the other alloy to a controlled depth and concentration. The controlled mixing of the powders provides an interface zone which, after consolidation and treating of the preform to a final near net shape, has properties lying between those of the two alloys, and there is no sharp bonding line. The basket (14) is removed by decomposition or melting and extraction or evaporation or incorporation in one or both of the powdered alloys.



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METHOD OF PRODUCING A MONOLITHIC ALLOY COMPONENT PREFORM

This invention relates to a method of producing a monolithic alloy component preform.

In highly loaded structures and components, such as gas turbine rotors, the range of properties required very often extend beyond that which is available from a single alloy. As a result of this, various schemes have been proposed and/or tried wherein one component or part is composed of two portions welded, brazed or diffusion bonded together. Generally, however, such methods do not provide the desired bond quality and also often cause a reduction in properties on or near the interface between the two portions.

According to the present invention the different alloys and properties thereof are utilized in a single component by bringing the alloys together in powder form prior to powder consolidation. Such consolidation may be hot isostatic pressing (HIP), consolidation at atomspheric pressure (CAP) etc.

According to one aspect of the invention, a method of producing a monolithic powdered alloy component preform from at least two different powdered alloys comprises the steps of placing the powders adjacent each other and consolidating the alloys, and causing a controlled mixing or diffusion of the powdered alloy particles or elements therein in an interface zone prior to or during the consolidation step or possible further metallurgical treatment.

The invention also comprise a method of producing a multi-alloy component preform by powder metallurgy comprising the steps of introducing the powdered alloys into an outer mold or can having an inner shape corresponding to the outer shape of the desired preform, substantially confining the main bulk of each powdered

alloy to a predetermined portion of the preform by providing a confining means substantially separating two different alloys and defining an interface therebetween and subsequently substantially removing said confining means, consolidating said powdered alloys into a preform, and causing a controlled mixing or diffusion of the powdered alloy particles or elements therein in an interface zone prior to or during the consolidation step or possible further metallurgical treatment, thus producing an interface alloy.

The invention will now be described in more detail solely by way of example, with reference to the accompanying drawings, in which :-

Fig. 1 is a fragmentary, axial, cross-sectional view of a radial flow turbine wheel preform,

Fig. 2 is a cross-sectional view of the preform illustrated in Fig. 1 along the line II-II thereof,

Fig. 3 is a diagrammatic vertical cross-sectional view of an apparatus for introducing the powdered alloys into the outer mold or can in the production of a disc-shaped preform having concentric alloy portions,

Fig. 4 is a fragmentary cross-sectional view of a mold with an enclosure means or basket defining a zig-zag-shaped interface,

Fig. 5 is an axial cross-sectional view of a mold with a non-cylindrical basket,

Fig. 6 is a diagrammatic illustration of the typical changes in the outer shape and the interface when producing a final turbine wheel from a preform of the type illustrated in Fig. 1, and

Fig. 7 is a diagrammatical cross-sectional view of a component preform comprising three different powdered alloys.

In Figs. 1 and 2 a radial flow turbine wheel preform 10 is shown to consist of an inner hub portion of alloy B and an outer blade portion of alloy A bonded together into

a monolithic component at an interface or rather an interface zone 11.

In Fig. 3 the method of producing such a preform in the form of a cylindrical disc having concentric alloy portion is diagramatically illustrated. The preform is initially shaped by means of an outer mold or can 12 which the powdered alloys fill. The outer can 12 is positioned in an enclosure 13 placed under vacuum or filled with inert gas to prevent oxidation of the powder particles as well known in the art. To substantially separate the two powders, a confining means in the form of a basket 14 is positioned concentrically within the outer can 12. The two concentric compartments on either side of the basket 14 are filled with the two alloys as indicated. The interface-forming basket 14 may have a grid or screen structure, or it can be made from a perforated sheet, as a zig-zag wall with or without perforations, as a smooth wall etc. The purpose of the basket is one or more of the following:

1) To separate the main bulk of the two alloys.

2) To define the "macro"-geometry of the alloy interface.

3) To allow a controlled mixing of some of the powdered alloy particles in an interface zone on either side of the interface-forming basket to provide an interface zone consisting of an interface alloy compatible with both alloy A and alloy B. Alternatively, such an interface zone may be formed by diffusion of elements of one alloy into the other.

4) To provide a source of alloying elements needed
   a) for the interface alloy as such or
   b) to supply one or more alloying elements to either of the alloys A or B to compensate for depletion of elements caused by diffusion from alloy A to alloy B or vice versa.

The controlled mixing of the powdered alloy particles to provide the interface zone can be obtained by allowing a controlled flow of one powder into the other through the basket 14, when in form of a grid, a screen or the like. For that purpose the filling operation may be controlled so that the rising powder level in one compartment precedes that in the other by a fixed or variable height (h) so that a powder flow from one to the other compartment can take place above the level in the other compartment with the only restriction being offered by the grid itself. In determining h the specific gravity of the two powders as well as other factors which will influence the behaviour of the flow of powder into the other compartment will have to be taken into account. The height h and/or the restriction offered by the grid can be controlled to vary the amount of mixing of one alloy into the other and/or the thickness of the resulting interface zone. Variation of the latter can be used to compensate for interface zone slimming during subsequent forging of the preform. The controlled transfer of portions of one powdered alloy into the adjacent layer of the other powdered alloy can also be achieved in other ways, for instance by rotating the inner basket 14 or even rotating the basket as well as the outer can 12 using the centrifugal force to provide said controlled transfer. Shaking would be a further alternative. Instead of transferring powder particles, merely one or more elements of one alloy may be transferred across the interface to form an interface zone, and this may be accomplished by diffusion when the basket 14 has been removed prior to or during the consolidation step or possible further metallurgical treatment.

A zig-zag type basket as shown in Fig. 4 would provide a considerable interface zone by diffusion alone.

The basket 14 may be removed by decomposing or melting the material in the basket whereupon the molten or

decomposed material is extracted and/or evaporated. However, as mentioned above, the material may also be incorporated in one or both of the alloys A or B or in the interface alloy.

Both the basket 14 and the outer can 12 may have different shapes in order to give the best final outer shape and interface configuration as illustrated in Fig. 5 for the basket 14.

After the powder preform has been consolidated, for example by hot isostatic pressing, it may be subjected to superplastic or hot die forging in which the material will flow into its near net shape. The turbine wheel blank would then be ready for heat treatment and final machining. Hot isostatic pressing may be used to shape the preform to final near net shape instead of merely for consolidation purposes.

The method described will provide a sound monolithic structure without the many uncertain aspects connected with diffusion bonding of solid parts. Also, the interface alloy will provide a compliance zone between the two alloys which for example could have a coefficient of expansion between those of the alloys A and B after the powder preform has been consolidated. A pressing and/or forging operation can follow which will give final dimensions prior to machining, as shown as an example in Fig. 6, in which the interface is indicated at 11 before forging and at 15 after forging. The outer contour of the preform is indicated at 16 and that of the final turbine wheel at 17. The line 16' indicates the contour between the blade and the hub portion of the turbine wheel. Trial and error methods will have to be used to determine the interface configuration 11 in the preform 10 which will result in the desired interface configuration 15 in the final component. The interface alloy now has properties which lies between those of A and B. Thus, there is no sharp "bonding line" between the two alloys.

A preform according to the invention can consist of more than two alloys and more than one basket 14. Also, a basket can be pre-loaded with powder prior to inserting the basket into the outer can. This is illustrated in Fig. 7, in which a basket 14' preloaded with powdered alloy B and a basket 14" preloaded with powdered alloy C may be placed into the outer can 12, whereupon a powdered alloy A may be introduced to fill the remaining space between the two baskets. In this instance, the baskets would have an internal air tight seal 18 of a material which would easily be decomposed and may be extracted or absorbed into the powder on either side of the basket when exposed to the operation temperature of the consolidation process or to other influences.

In the example in Fig. 7 material C could be an alloy which is resistant to corrosion and abrasion at high temperature, whereas the requirement for high ultimate tensile strength is less than for the alloys A and B. The alloy B would be the alloy of the highest tensile strength. The properties of alloy A would fall between those of alloys B and C.

The method of the invention has the potential of giving turbines the ability to operate at very high temperatures and tip-speeds without incurring risk of failure by inadequate and unreliable bonding. The method offers numerous interface geometry choices for the optimization of the structural properties of the finished turbines.

In the specification the term "alloy" should be taken to refer to any solid, structural composition composed of two or more chemical elements of which at least one is a metal, providing this composition lends itself to powder metallurgy processing methods including consolidation steps. Thus, not only mixtures of elemental metals, but also compositions such as metal carbides and ceramic materials are comprised by the term "alloy" as used in the present Specification.

CLAIMS:

1. A method of producing a monolithic alloy component preform, characterised by the steps of placing at least two different powdered alloys adjacent each other and consolidating the alloys, and causing a controlled mixing or diffusion of the powdered alloy particles or elements therein in an interface zone prior to or during the consolidation step or possible further metallurgical treatment.

2. A method of producing a mult-alloy component preform, characterised by the steps of introducing a plurality of powdered alloys into an outer mold or can (12) having an inner shape corresponding to the outer shape of the desired preform, substantially confining the main bulk of each powdered alloy to a predetermined portion of the preform by providing a confining means (14) substantially separating two different alloys and defining an interface therebetween and subsequently substantially removing said confining means (14), consolidating the powdered alloys into a preform, and causing a controlled mixing or diffusion of the powdered alloy particles or elements therein in an interface zone prior to or during the consolidation step or possible further metallurgical treatment, thus producing an interface alloy.

3. A method according to claim 2, characterised in that the material of the confining means (14) provides alloy elements to one or both of the alloys adjacent the interface therebetween defined by said confining means (14).

4. A method according to claim 2 or 3, characterised in that the confining means (14) allows a transfer of a controlled portion of one of the alloys into the other

alloy in order to provide an interface alloy compatible with the two alloys on either side of the interface defined by the confining means (14).

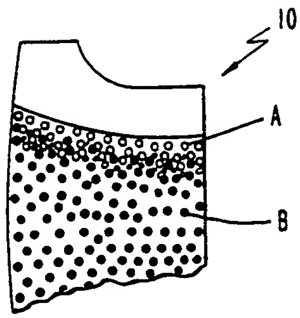
5. A method according to claim 4, characterised in that means (14) has a grid or screen structure through which a controlled portion of one of the powdered alloys may flow when there is no powder on the other side of said confining means (14).

6. A method according to claim 4 or 5, characterised in that the confining means (14) allows diffusion of a portion of one of the alloys into the other alloy prior to or during the consolidation step.

7. A method according to any of the claims 2 to 6, characterised in that the confining means (14) defines an interface having a large number of protrusions and/or recesses from the overall geometric shape of the confining means thereby providing a bonding interface zone even without transfer of powder particles across the interface.

8. A method according to any of the claims 2 to 7, characterised in that one alloy is preloaded into a confining means (14) which is inserted into the outer can (12), whereupon the rest of the can (12) is filled with the other alloy.

Fig.1



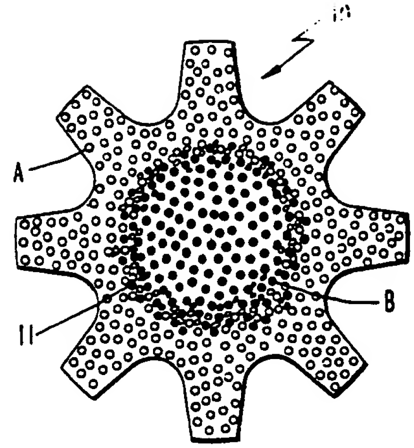


Fig.2

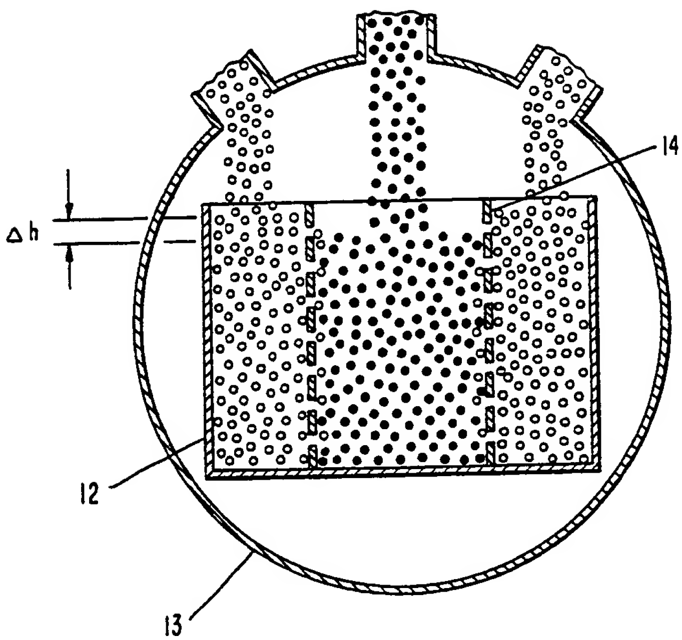


Fig.3

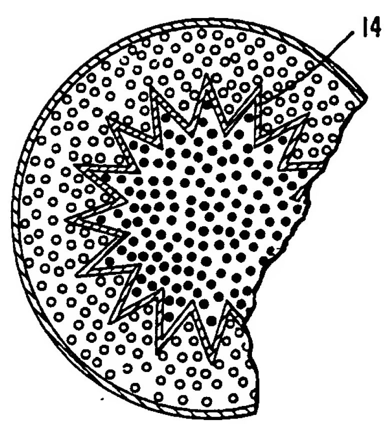


Fig.4

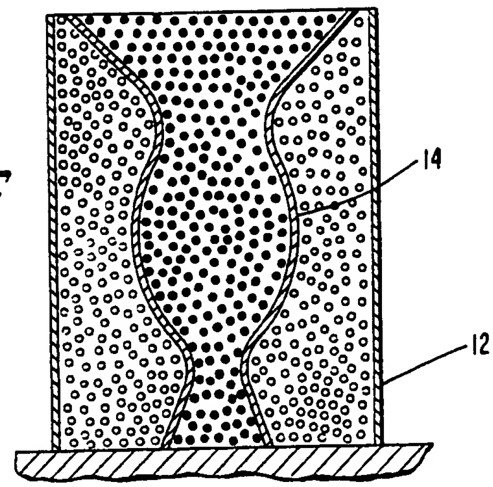


Fig. 5

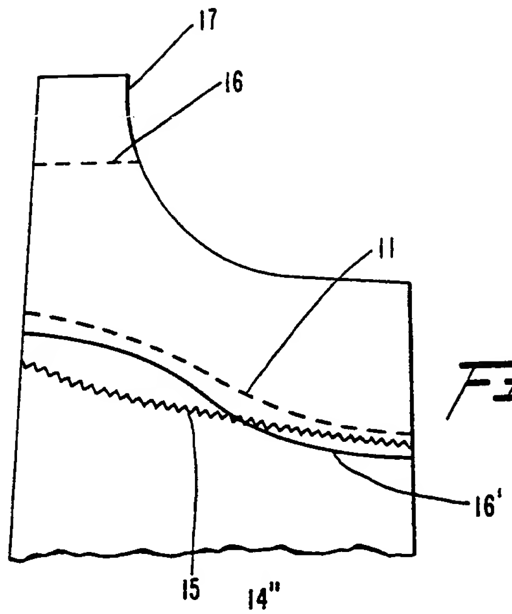


Fig. 6

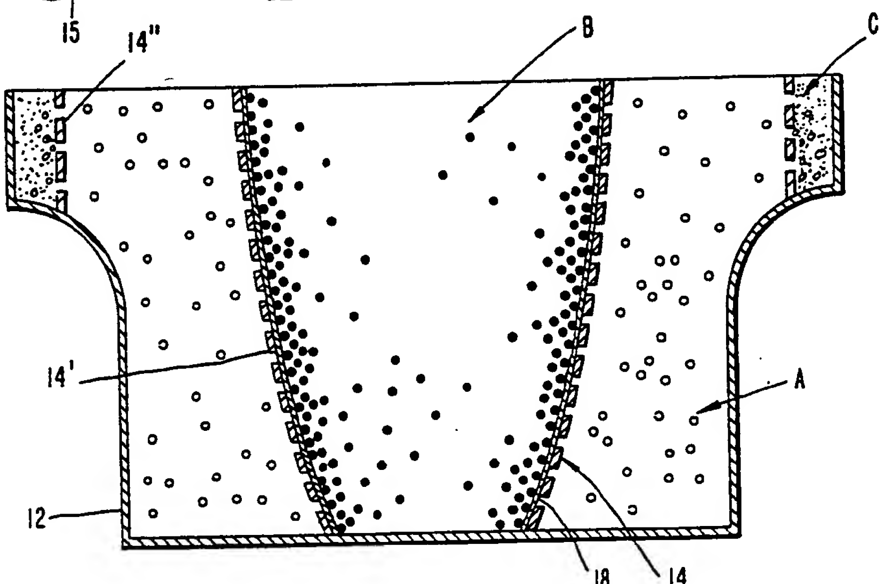


Fig. 7

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Application number

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EUROPEAN SEARCH REPORT

EP 82 30 4080

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X,Y	US-A-3 510 935 (E. DÜRRWÄCHTER et al.) * Claim 1; Column 5, line 61 - column 6, line 10 *	1-7	B 22 F 7/06
Y	GB-A- 530 639 (MEUTSCH, VOIGT-LANDER & CO.) * Claims 3; page 1, line 98 - page 2, line 25; page 2, lines 80-94 *	3-6,8	
A	US-A-3 862 286 (R. COUCHMAN)		
	-----		TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			B 22 F 7/06

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25-10-1982	SCHRUERS H.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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